DOCUMENT RESUME

ED 416 666 EF 005 023

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TITLE Review of Research on the Relationship between School Buildings, Student Achievement, and Student Behavior.

INSTITUTION Council of Educational Facility Planners, International, Scottsdale, AZ.

PUB DATE 1996-10-08

NOTE 18p.; Paper presented at the Annual Meeting of the Council of Educational Facilities Planners, International (Tarpon Springs, FL, October 8, 1996).

PUB TYPE Information Analyses (070) -- Speeches/Meeting Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS *Academic Achievement; Classroom Design; *Educational Environment; *Educational Facilities Design; Educational Facilities Planning; Elementary Secondary Education; Facility Case Studies; School Buildings; School Construction; *Student Behavior; Thermal Environment; Visual Environment

ABSTRACT

The most persistent question in the field of school facility planning relates to that of the relationship between the built environment and the performance and behavior of users, particularly students. Ways in which the built environment affects two student variables--student achievement and student behavior--are explored. The first variable is student achievement as measured by some form of standardized or normed test, or examination administered to all students in the schools under study. The other variable is student behavior that can include specific level of student activity or school climate. A survey of research summarizes open-education programs and open-space schools, school building age, thermal factors, visual factors, color and interior painting, hearing factors, open space, windowless facilities, underground facilities, site size, building maintenance, and numerous other factors. All of the studies demonstrated a relationship between student performance--both achievement and behavior--and the condition of the built environment. The relationship varied from very weak in some early studies to a considerable degree of relationship in recent studies. Some of the more important factors that were found to influence learning are those relating to control of the thermal environment, proper illumination, adequate space, and availability of equipment and furnishings, particularly in science education. Some areas of needed research are discussed. (Contains nine references.) (RJM)

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REVIEW OF RESEARCH ON THE RELATIONSHIP BETWEEN SCHOOL BUILDINGS, STUDENT ACHIEVEMENT, AND STUDENT BEHAVIOR

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Council of Educational Facility Planners, International
Annual Meeting
Tarpon Springs, Florida
October 8, 1996

EF 005 023

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INTRODUCTION

The most persistent question in the field of school facility planning relates to that of the relationship between the built environment and performance and behavior of the user. This question has intrigued researchers and practitioners for decades. People want to know the built environment has an effect, especially upon students in a school. There are those researchers who state that the building has such insignificant influence upon the user that whatever effect is evident is simply that of chance. Other researchers, however, state that the built environment does have a discernible influence upon the process of teaching and learning. These individuals state the users are influenced both positively and negatively by how the built environment either permits them to function or inhibits the process of teaching and learning, yet systematic analysis of this question on a large enough scale to generalize or predict has not been undertaken.

The main emphasis of investigation in this position paper is the relationship between the built environment and at least two student variables. The first variable is student achievement as measured by some form of standardized or normed test or examination administered to all students in the schools. The other variable is student behavior that can include specific level of student activity or school climate that is a more general term. These two variables relate directly to students themselves. There is a common belief that the behavior of students influences their academic achievement. The reverse is also well documented in that achievement influences behavior in students.

Perhaps the major limitation on this type of research is determining the degree to which school facilities can be the actual cause of student behavior and achievement. When one realizes the many variables that influence how much students can and do learn and how students behave, it is evident the built environment perhaps has a very limited role to play. Obviously, the most important variables that influence how students learn come from the genes their parents impart to them and the home environment they create for their children. Then in descending order are variables such as natural surroundings and conditions beginning from the day of birth to the very day the student enters the school building that subsequently influence the activities of students. Only then can the building play any part in how students learn. Depending upon what expert in learning theory is read, the

amount of variance the built environment plays in influencing learning and behaving is either non-existent or at best is limited. Even if the variance the built environment can account for is slight, the important fact to remember is that there is a portion of the variance that then can be controlled through efforts of educators and design professionals.

SURVEYS OF RESEARCH

Two researchers have provided compilations of research findings that serve as seminal works to guide other researchers in further work. One such document was done by Carol Weinstein and reported in the Review of Educational Research in 1979 (p. 577). In her review of research on building influence upon students, a total of 141 published studies plus 21 additional references that were paper presentations at various professional organizations were cited in the analysis. Three years later, Carroll McGuffey completed another monumental review of research in a book on educational productivity edited by Walberg (1982). McGuffey cited 88 separate published studies in his review. In a further discussion of the topic accompanying the writings of McGuffey, O'Fallon and Young listed and reviewed an additional nine studies (1982). These two reviews by Weinstein and McGuffey cited a total of 238 research studies plus 21 paper presentations. In this number of citations there were only six that were cited by two or more authors -- an overlap of less that 3 percent of the studies -- which means that 232 separate research studies were cited by these reviewers.

What did these researchers find after reviewing all of these studies? One would think a great deal of hard data would be available to the school facility planner and design professional in doing their work. Even with this large number of research studies, it is difficult to determine any definite line of consistent findings.

The main thrust of the research cited by Weinstein involved the open education programs and the open space schools. Much of the research she presented is probably less relevant today than 30 years ago. Open space classrooms were quite popular during the late 1960's and early 1970's but by the end of the 1970 decade, the trend of planning and designing open space classrooms had diminished, if not completely stopped.

In his synthesis of research, McGuffey acknowledges that the explainable variance in learning that can be attributed to the school building is small. When the total amount of variance accounted for by all school-related variables is small, perhaps the impact of the school building itself then takes on added importance. In other words, the variable of the school building may be large when considered in relationship with all the variables over which the school system has control.

He put forth two conclusions as a result of the review of research. The first conclusion stated that old and obsolete buildings do have a negative effect upon the learning process of students, whereas safe, modern, and controlled environment facilities enhance the learning process. He also stated that school facilities may have a differential impact upon the performance of students in different grades and subjects. In other words, whatever impact school facilities may have upon students may be greater in certain grade levels and subject areas than in others. The longevity and student age factors may play a part in determining the effect a building has upon the users.

McGuffey cautioned his readers about the difference in the studies included. At best the studies are a ". . .mixed bag of study types and methodologies presenting diverse problems of sampling, measurement, and statistical analysis" (p. 272). With such a wide divergence of studies, a reviewer must be careful not to place too much credence upon findings in each study because of the uneven nature of the investigations. In addition, reviewer bias has to be modulated to give equal balance where necessary. Some studies are simply more rigorous than others and use a larger population for data gathering, consequently all studies can not be treated equally. This presents a problem for the serious researcher in deciding which studies to include in presenting the results.

McGuffey used 15 categories of variables to report the research he included in his analysis, yet the number of studies in any of the categories was not large and as a result, it is difficult to generalize when there are a small number of studies (p. 288).

Although there may be some argument regarding the division of variables, nevertheless, these are the major variables that have been used in research on the learning environment. McGuffey adhered to these categories in reporting research findings which were synthesized.

School Building Age- Under this variable, seven studies were reviewed by McGuffey. In all cases the building age was significant as a contributor to student achievement and behavior. Minor differences in significance were noted on selected grade levels and subjects. Building age can also serve as a surrogate for a number of specific variables such as condition of the building, thermal control, proper lighting, acoustical control, support facilities, condition of laboratories, aesthetic condition of the environment, just to name a few. Nevertheless, school building age is a significant variable that influences student learning and behavior.

Therman Factors- The thermal environment of a classroom seems to be very important to the well being and efficiency of students. Nine studies were included in the review and eight of the studies found a significant relationship between a controlled environment and student achievement and behavior. Even though there were methodological limitations, the persistence in the relationship across the studies indicates a very positive relationship.

Visual Factors - There have been more studies in this area than in any other single area. Many of the studies have been conducted by the Illuminating Engineering Society in controlled environments. Ten studies conducted in schools were reviewed and in all cases, good lighting quality and proper foot candles were found to be positively related to increases in student achievement and performance.

Color and Interior Painting - There has been a great deal of research done outside of the field of education on the effect of color on the performance of a building user. These studies have unequivocally identified certain colors as contributing to increased performance by the worker. Some of the findings in these studies have been used in subsequent research studies in school buildings. In this review of research, five studies were included. Four of the five studies found that color had an impact upon student achievement. The fifth study found significance in only one room of fourteen classrooms being studied. Nevertheless, the preponderance of evidence suggests a relationship between color and student achievement.

Hearing Factors - The studies reviewed for this variable ranged in dates from 1917 to 1963, and yet only seven studies were cited. All seven, however, indicated a significant impact upon student learning. Six of the studies used unwanted noise at high decibel levels to demonstrate the adverse effect upon learning. Although there is little doubt that noise can effect learning, the level of noise must be at the extreme level to have significant impact. There is a great range of noise level that is permissible and still have efficient learning. Generalizing from these studies is not possible because of the methodological problems inherent in the work. With the high decibel level of music that youths of today are accustomed to, perhaps the results of these studies are not as usable today as previously thought.

Amount of Space - Only two studies dealing with space allocation per student were reviewed in this chapter. The findings of these studies were mixed and as a result, generalizations can not be made.

Open Space - Open space schools are no longer planned and designed in most countries in the Western Hemisphere and as a result the findings of the studies reviewed for this category are not relevant today, however, nine studies were included in the review. Open space was positively correlated with student achievement, performance, and self-concept in these studies, however, the findings in these studies are mixed at best. Students in traditional schools performed significantly better than their counterparts in open space schools on self-concept, which is contrary to what Weinstein found in her review of research. The results of the studies using achievement as a variable showed mixed results. Only on the non-cognitive variables, other than self-concept, did the students in the open space schools score better than students in traditional schools. These results mirror and support most of what Weinstein found in her larger review of research studies on open space schools.

Windowless Facilities - Only one study was included dealing with this topic and that was Larson's study of 1965 that was reported above in this chapter. Regardless of how one feels about windowless spaces, the research does state rather clearly that classroom windows or lack of windows has little, if any, effect upon the performance of students.

Underground Facilities - Few, if any, schools are constructed underground today. During the early 1960's the federal government was interested in fallout shelters and gave funds to local school systems to experiment with underground schools in New Mexico. One study was completed on these schools to correlate student achievement, attitude, and anxiety with the facilities. The researchers compared these variables for students in underground and above ground facilities. The study showed no difference between student achievement, attitude or anxiety and students in either underground or above ground schools. These results corroborate the findings of Larson on windowless schools.

Site Size - A small number of studies were included here. Three studies were cited where site size was compared with student achievement, performance, and self-concept. Two studies

showed some relationship on several regression runs, but not enough for a definite conclusion. The third study was descriptive only.

Building Utilization - Utilization of a building is a result of administrative decisions and building utilization can vary considerably. Two studies were included in this review, but no significant relationship was found in either one when comparing student achievement and behavior to the utilization of a building.

Building Maintenance - Proper maintenance can keep a building in good repair and poor maintenance can cause a building to rapidly deteriorate. The relationship between the condition of a building and student attitudes and behavior was reported in one study cited here. As can be expected, students in the newly modernized building had better attitudes and fewer disciplinary behaviors than students in school buildings that were old and dilapidated.

Support Facilities - Several studies explored the relationship between selected support facilities and student achievement. Two studies used gymnasium, auditorium, and cafeteria as support facilities and found mixed results. Seven studies used either the number of library volumes or the number of volumes per student as a measure to compare student achievement and behavior. Only three studies of this group showed significant positive results and the rest showed either mixed results or no significant relationship. As a result of all of these studies the findings do not support a positive relationship between support facilities and student achievement and behavior.

Special Instructional Facilities - Two studies used the presence or absence of science laboratories or equipment as variables in regressing against student achievement. In both studies a significant positive relationship was found.

Size of School - A total of sixteen studies was included in this category. Only four studies considered student achievement in relationship to size of school. In all cases a significant positive relationship was found between the size of school and student achievement. The larger the school the higher the student achievement was. The remainder of the studies dealt with the size of the school and program offerings in the curriculum or the space devoted to special instructional facilities. One might conclude from this analysis that indeed the larger the size of the school, the better the students achieve. There are studies, however, that have been completed since the analysis by

McGuffey that indicate that size may not be necessarily identified with increased student achievement, but at least these studies suggest that possibility.

With all of the above studies cited, one must conclude that school facilities do indeed effect student achievement and behavior and for the most part those school buildings that are in a good state of repair containing modern equipment do provide a positive environment for students to succeed.

REVIEW OF RECENT STUDIES

Conventional wisdom in the area of educational facility planning and design seems to indicate that the physical environment does indeed have an effect upon the behavior, achievement, and performance of the students and teachers who occupy these spaces. So often, however, a significant relationship is difficult to statistically demonstrate.

Edwards investigated the relationship between parental involvement, school building condition, and student achievement in the schools in Washington, D.C. (1992). She hypothesized that the condition of public school buildings is affected by parental involvement and that the condition of the school building further affects student achievement. She analyzed these relationships by evaluating the condition of school buildings, determining the extent of parental involvement and fund raising for the local school, and compared the results with student achievement scores.

For the first part of her hypothesis dealing with parental involvement, Edwards found that in those schools where large numbers of parents were involved through membership in the PTA and raised considerable funds for school purposes, the buildings were in better condition than those buildings where parents were less involved in school activities and who raised less money for school purposes. For every dollar increase in the PTA budget of the school, the building was seen to improve on the scale of building condition.

The second part of the hypothesis dealt with building condition and student achievement; the analysis of data supported that hypothesis. Building condition did have an affect upon student achievement scores. The analysis indicates that as a school moves from one category to another, the achievement scores can be expected to increase by 5.455 percentage points. If the school moves two categories, such as from poor to excellent, the achievement scores would be expected to

increase by 10.9 percentage points in the average achievement scores. Conversely, based upon the analysis, "the signs of the estimated building condition coefficients are negative, meaning that from our base of excellent schools, a building condition of fair or poor [school buildings] will reduce the average student achievement score" (p. 24).

In a similar study, Cash investigated the relationship between certain school building conditions, student achievement, and student behavior in rural high schools in Virginia. The condition of the school buildings in this study was determined through evaluation by local school system personnel. Cash developed a data gathering instrument to be used by local school personnel. This instrument was based upon existing research that addressed certain building conditions. Each item was derived from other research studies that had been completed and which showed a positive relationship between specific building condition and student achievement and behavior.

The results of the analysis indicated a positive relationship between building condition and achievement of students. In all of the subtests of the Test of Academic Proficiency (TAP), academic performance was positively related to the condition of the school building. Cash found that student achievement was higher in those buildings with higher quality ratings. The difference in percentile rankings was as much as 5 percent. The comparison between cosmetic building category and achievement had higher levels of achievement than when the structural building category was compared with achievement. Student achievement in the science section of the TAP was higher in those buildings with better quality science equipment than in those buildings with lower quality science facilities. The difference between low and high rated schools was seven percentile ranks.

For the comparison between student behavior and building condition, there was a positive relationship, but in a reverse manner. The better quality schools had higher ratios of disciplinary incidents, expulsions, and suspensions than did schools with low building conditions. This reverse relationship was not explicable by the data, but Cash theorized that faculty in the better quality schools was perhaps stricter in the application of disciplinary policy than faculty in lower rated buildings with a resulting higher incidents reported.

A similar study on a state-wide basis was conducted by Earthman, Cash, and Van Berkum (1995). The researchers used the same methodology as the Cash study. The study was conducted in North Dakota and included all 199 high school buildings in the state. The instrumentation used in

this study was a modification of the original instruments from the Cash study. Again, a self evaluation methodology was utilized to obtain the rankings of substandard, standard, and above standard buildings. In addition, the items of the instrument were categorized to create cosmetic and structural categories for comparison purposes.

Student scores on the Comprehensive Test of Basic Skills (CTBS) administered to all 11th graders throughout the state was used for student achievement. Again, scaled score means for each building was the measure used for comparison purposes. In all sub-tests of the CTBS except two, the students in above standard buildings outscored students in the substandard buildings. There was no difference in scores on the Social Studies sub-test between the building categories, and on the Math Total sub-test there was a one percentile rank difference in favor of scores in the substandard buildings. The range of differences in the scores in all other sub-tests between the two building conditions was from 1 to 9 percentile ranks.

When the cosmetic building condition was compared with achievement, the differences were evident in all sub-tests except Language Mechanics where there was no difference in achievement scores. All of the sub-tests, except the one above, showed a difference in favor of the above standard buildings. The range of these differences was from 4 to 11 points.

Although the average percentile rank differences were not as great as those found in the Cash study, this study does support the findings of both the Edwards and Cash studies. Both of these researchers found at least a 5 percent difference in achievement scores in their population. The North Dakota study resulted in a similar difference of percentile rankings in student achievement scores.

A fourth study using the same basic methodology and was a replication of the Cash study was recently completed using large, urban high schools in Virginia as the population. Hines used the same methodology and data gathering instrument that Cash used on small, rural high schools (1996). His results in comparing building condition and student achievement were basically the same as hers. The range of his differences between below standard and above standard buildings, however, were greater than what was found in her study of rural high schools and in the North Dakota high schools study. Some of the differences were as high as 11 percentile ranks. This compares favorably with the results Edwards got in her comparison between the worst and best school buildings. Edwards

stated that the difference in mean achievement scores in her study population was as much as 10 percent between school buildings in the substandard and above standard categories (p. 24).

The Hines study is the latest in a series that were completed by researchers trying to explore the relationship between school building condition, student achievement, and student behavior (1996). The basic methodology was the same for all four studies and the results seemed to be consistent. The only difference between the study results seemed to be in the degree of difference in the mean scores of achievement examinations between schools in the lowest category and those in the highest. One might conclude from these studies that indeed the building does contribute to the variance in student performance. The degree of this contribution may vary slightly, but is constant within a narrow band of influence.

All of the four studies cited above used a factor of building condition to classify school buildings for analysis purposes. The building condition factor was used to classify buildings into sub-standard, standard, or above standard categories depending upon how the building was evaluated. In all of the studies, the building factor was made up of responses to questions relating to certain attributes or conditions in the building. Each question in the evaluative instrument was about building attributes and conditions that were individually identified in previous research studies to be directly related to either student achievement or student behavior. For instance, studies were completed using such separate building factors as air conditioning, classroom windows, thermal control, cleanliness of classrooms, age of building, lack of graffiti, how recent painting was completed, and the frequency of cleaning classrooms. Each of these factors went to make up the instrument used to determine building condition.

SYNTHESIS OF FINDINGS

All of the studies cited above have demonstrated a relationship between student performance, both achievement and behavior, and the condition of the built environment. The relationship has varied from very weak in some of the early studies to the most recent study which demonstrates a considerable degree of relationship. Nevertheless the preponderance of the research cited shows a very close relationship between the built environment and how well students and teachers perform in that environment.

Some of the most important factors that influence learning are those that relate to control of the thermal environment, proper illumination, adequate space, and availability of equipment and furnishings, especially in the subject area of science.

Four very recent studies demonstrated the positive relationship between building condition and student achievement and behavior. In addition, one of these studies demonstrated the relationship between parental involvement and the condition of the school building their child attended. This finding is a very significant one in that school building personnel can do something to assist in keeping the building in which students learn and they work in as good a condition as possible by enlisting the overt support of the parents group to raise funds and to pressure school boards to provide better conditions.

The range of differences in each of these four studies between the test scores of students in substandard and above standard school buildings was between 1 and 11 percentage points, but nevertheless, in all cases there was a positive difference for students in the better buildings. These findings are of particular importance because of the large number of school buildings across the country that are in substandard condition. The factors which determined the condition of buildings in these studies are usually incorporated in a new structure, but a large number of the existing school buildings do not have the benefit of these conditions, as witness the General Accounting Office study which documented the poor state of condition of the public schools in the United States (1995).

The results of these four studies can be played out in possible actions of educators and school board members to improve the educational opportunities of students. If, as the studies strongly indicate, the test scores of students in above standard schools increase above the scores on substandard buildings, then there are ways of increasing student test scores by improving the building. Spending funds to improve the built environment will produce greater results than funds spent on materials, textbooks, and even teachers.

AREAS OF NEEDED RESEARCH

What kinds of research is needed to help advance the knowledge base on how buildings influence student behavior and achievement? Four researchers investigated the relationship between building condition and student achievement and behavior. Is there sufficient data in these

studies to indicate this line of research has reached the end? As conclusive as these data are, there is still a need to expand the population beyond the level of one state, as beneficial as that study was. A study needs to be mounted that would include sufficient numbers of school buildings in a representative sample across the United States to serve as a point of generalization.

Secondly, more investigation is needed on the possible relationship of building condition and student behavior. In almost all cases, an inverse relationship was found between the building condition and student behavior. In other words, the better the building condition, the more discipline incidents were reported. A greater emphasis upon exploring this possible relationship needs to be made. To what degree does the building influence the attitudes and subsequent behavior of students? Several methods for investigating this relationship present themselves for implementation. All that is needed is someone willing to complete such a study.

Another area of needed research deals with the possible relationship between the leadership and financial ability found in the school system and the condition of the schools. Does the leadership provided by the administration and school boards determine the condition in which the schools are which in turn influences the attitudes of students? Again, several methods of investigation suggest themselves to this question.

The above questions are not in isolation from each other or the base of research used in this presentation. Rather, the questions follow a theoretical model which tries to explain how the condition of the school is determined, how the building influences attitudes of parents, teachers, and students, and how these in turn influence the achievement and behavior of students. Only by using a theoretical model to explain phenomena related to school building influence, can efficient and effective research take place and produce some usable results.

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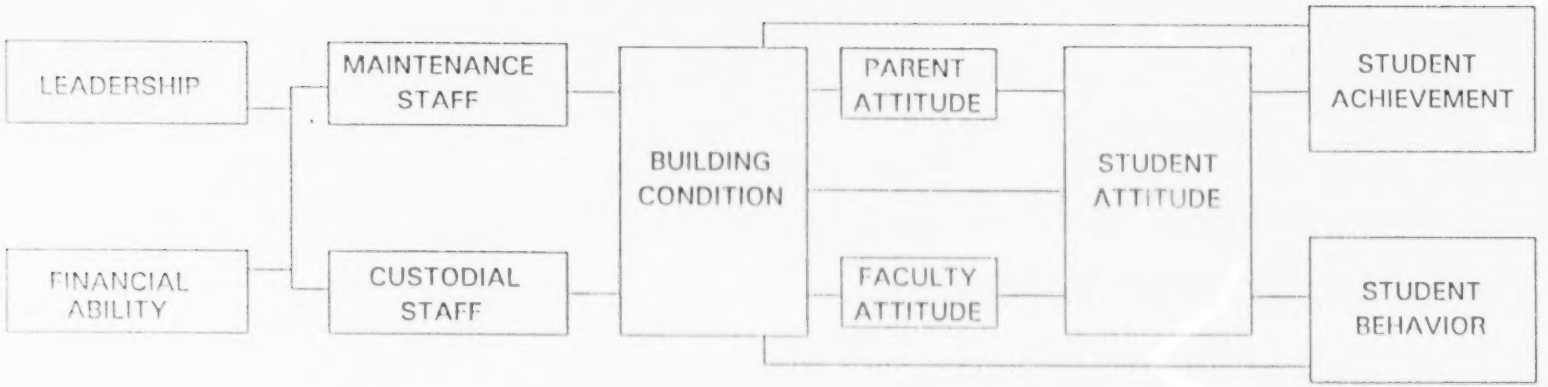

MODEL DESIGN
Figure 1

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